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TRANSITIVE INFERENCE AND COMMONLY CODED STIMULI

by

WILLIAM T. SUITS

(Under the Direction of Janice N. Steirn)

ABSTRACT

This experiment examined whether stimuli that were commonly coded through association with similar outcomes would be treated differently when used in a transitive inference (TI) task than stimuli not commonly coded. A TI task was used in which stimuli were presented to pigeons as pairs (A+B-, B+C-, C+D-, D+E-), and a single pair of stimuli was presented as a test (BD). Pigeons were assigned to four groups in which stimuli were associated with one another along the linear array. For the Within Common Coding Group, the outcomes were arranged so that B and D both received the same outcome (when positive in their respective pairs). For the Between Common Coding Group, the outcomes were arranged so that B and D received different outcomes. Random outcomes were assigned to stimuli in the Control Group. Results indicate that the stimuli did not become commonly coded and the manipulations may not have worked.

INDEX WORDS: Pigeons, Transitive Inference, Common Coding

TRANSITIVE INFERENCE AND COMMONLY CODED STIMULI

by

WILLIAM T. SUITS

B. A., Georgia Southern University, 2003

M. S., Georgia Southern University, 2005

A Thesis Submitted to the Graduate Faculty of Georgia Southern University in Partial
Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

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2005

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TRANSITIVE INFERENCE AND COMMONLY CODED STIMULI

by

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Chapter 1

Introduction

Transitive Inference and Commonly Coded Stimuli

Transitive Inference (TI) is a process in which a relationship can be inferred between items on a linear array that have not previously been trained together based on intermediate items. An example of transitive inference is if someone is told that Janice is taller than John and John is taller than Kate then that person could reason that Janice is taller than Kate (Weaver, Steirn & Zentall, 1997). The question of how transitive inference works has long been in debate.

Piaget (1928) as cited in Fersen, Wynne, Delius and Straddon (1991) did not believe that a child could complete this type of task until he or she reached seven years of age or older. Piaget traditionally presented this type of task as a verbal syllogism so that the presentation of all information had to be arranged mentally as the child heard it. Piaget's reasoning was that a person's transitive ability should be demonstrated through the use of a broad range of abilities (Fersen et al., 1991).

Bryant and Trabasso (1971) disagreed with Piaget (1928). They proposed that the task could not be done verbally because of memory limitations, but if the child had a reference between the different stimuli then he or she should be able to complete the task. They created a five-term series task in which children were taught to label pairs of rods by length and color.

In Bryant and Trabasso's (1971) task, the children could not see the length of the different rods. Instead they were only able to see a comparison of two different rods, in a five rod set. After one set had been presented and taken away, a new set of rods that included one of the previous rods and a new rod was presented. The child would then

determine if one of the rods was longer or shorter than the one with which it was paired. For example, in one presentation the red rod was longer than the green rod and in the following presentation the green rod would be longer than the white rod. There were five different lengths used in order to control for end effects. When children were tested on a pair that had not been seen together before, yet had been reinforced equally, the children were able to successfully perform the task of determining the comparison lengths of the rods at a high rate. This held true for children as young as four years of age (Bryant & Trabasso, 1971).

This paradigm was then applied to various species of nonhumans to determine if animals could complete the task using the same technique. It was found that squirrel monkeys were able to complete this task (McGonigle & Chalmers, 1977). Chimpanzees had also demonstrated a tendency to follow transitive inference rules (Gilliam, 1981). It was thought that animals could use this task because in nature a creature must be able to rank alternative choices according to desirability even if they have never encountered the specific pairing of the choices before. Therefore, it is presumed that the ability to make a transitive inference is in some form adaptive in nature and therefore can be successfully demonstrated in primate behavior (Fersen et al., 1991).

Fersen et al. (1991) were the first to test pigeons on a TI task. They wanted to explore whether or not pigeons had the ability to make transitive inferences between two stimuli not previously paired. They argued that it was a simple learning mechanism for the animals to learn which of the two previously non-paired stimuli had a greater value. The task used five stimuli to control for end effects. The pigeons were trained on a five-stimulus task which was presented in pairs as follows: A+B-, B+C-, C+D-, D+E-. The [+]

designates a positive stimulus, the choice of which results in reinforcement. This task may be seen in Figure 1.1. The symbols of ABCDE are used to represent visual stimuli, which were shapes that are presented on a response key. After successful training to the stimuli the pigeons were tested with stimuli B and D, which had previously not been paired together. Pigeons showed above chance choice of stimulus B, demonstrating TI performance.

Various explanations of TI performance have been offered. Fersen et al. (1991) proposed that TI performance is a result of accumulated associative value between stimuli and reinforcers. Couvillon and Bitterman (1992) argued that TI performance is due to the history of reinforcement and nonreinforcement of each test stimulus (B & D). Markovits and Dumas (1992) proposed that pigeons were using a form of probabilistic inference based on context-specific information in which the pigeons transferred information that had a reinforcement value to stimuli that were physically associated with others that had a history of positive reinforcement.

Steirn, Weaver and Zentall (1995) wanted to establish a procedure that could replicate the performance that had been found in transitive inference tasks and then to provide a further explanation for the effect. Steirn et al. (1995) proposed that various TI studies had some training procedures in common with each other even though there was a difference in training performance and the time to complete training.

Steirn et al. (1995) were able to draw conclusions concerning which processes were most likely to account for transitive inference performance. Steirn et al. (1995) found that the difference in reinforcement history most likely does not have any implications for TI performance. However, they did suggest that the value transfer theory

Figure 1.1

Training sequence for a Transitive Inference task and the linear array in which the stimuli are placed.

A > B

B > C

C > D

D > E

A > B > C > D > E

Test: B ? D

could account for the preference for stimuli which the reinforcement history hypothesis could not (Steirn et al., 1995).

There have been other theories to explain how transitive inference works in pigeons. Wynn (1995) proposed one theory which stated that complex cognitive ability could be the result of familiar associative mechanisms. To explore this, he applied the simplest models that could possibly account for the varying details that are involved in a transitive inference task. After testing several models, it was determined that value transfer theory was the most probable model that simplifies the effects that occur in a transitive inference task. However, the models that were tested were not intended to determine how transitive inference works but merely to test different theories of conditioning towards the model. The value transfer theory most likely was the easiest fit not because it allowed for a direct transfer of value, but because it accounted for several indirect mechanisms that applied to the situation (Wynne, 1995).

Up until this time, it had been suggested, but not yet supported that value transfer theory was the most likely explanation for transitive behavior in nonhuman animals. Zentall and Sherburne (1994) found support for Value Transfer Theory. They suggested that when an animal makes the choice of stimulus B over D then it is probable that in a five-stimulus task, more value has been transferred from A to B than from C to D. The reasoning behind this argument is that stimulus A was always reinforced whereas stimulus C was only reinforced half of the time (Zentall & Sherburne, 1994).

Although there has been repeated empirical support to demonstrate that value transfer (VT) is a process that could be involved in a transitive inference task there are still alternative possibilities that need to be explored. For example, Steirn et al. (1995)

found that differential VT is not necessary in TI performance. Results from previous research had suggested that positive transfer of value is not the only process that could account for transitive inference in animal models. To test whether or not negative value plays a role in the transitive effects Weaver, Steirn and Zentall (1997) tested for both positive and negative value transfer on test stimuli.

They found that it was doubtful that either the differential reinforcement value, which was associated with the test stimuli in training, or the value that was transferred to stimuli was the reason for stimulus preference between B and D (Weaver et al., 1997). With these findings the argument that value transfer was the mechanism underlying transitive inference performance was not supported. Instead, Weaver et al. (1997) proposed that there may be a spatial ordering in effect during mapping of stimuli in memory. They cited work done with rats (Roberts & Phelps, 1994) that suggests that the animals form a cognitive map along a linear representation.

Roberts and Phelps (1994) argued that transitive inference might be represented in animal models by using a spatial organization similar to putting the stimuli along a line. They tested animals to determine whether the stimuli, when placed on a spatial continuum, would encourage a coding along a linear line. If so, this would be evidence of a spatial code. However, if the stimuli were arranged in a non-linear fashion then it should interfere with spatial coding (Roberts & Phelps, 1994).

Roberts and Phelps (1994) found that rats receiving a linear relationship among stimuli demonstrated significant transitive performance. However rats trained in a way that did not promote a linear pattern responded either in a random way or at least in a pattern that did not suggest transitivity. This experiment was useful in demonstrating that

rats can represent transitive problems through spatial coding (Roberts & Phelps, 1994).

It was stated earlier that transitive inference may be an adaptive process for animals in the natural environment so that they can make judgments about stimuli that they have never encountered together before (Fersen et al., 1991). However, there are other ways that an animal may use to make a judgment about relations among stimuli.

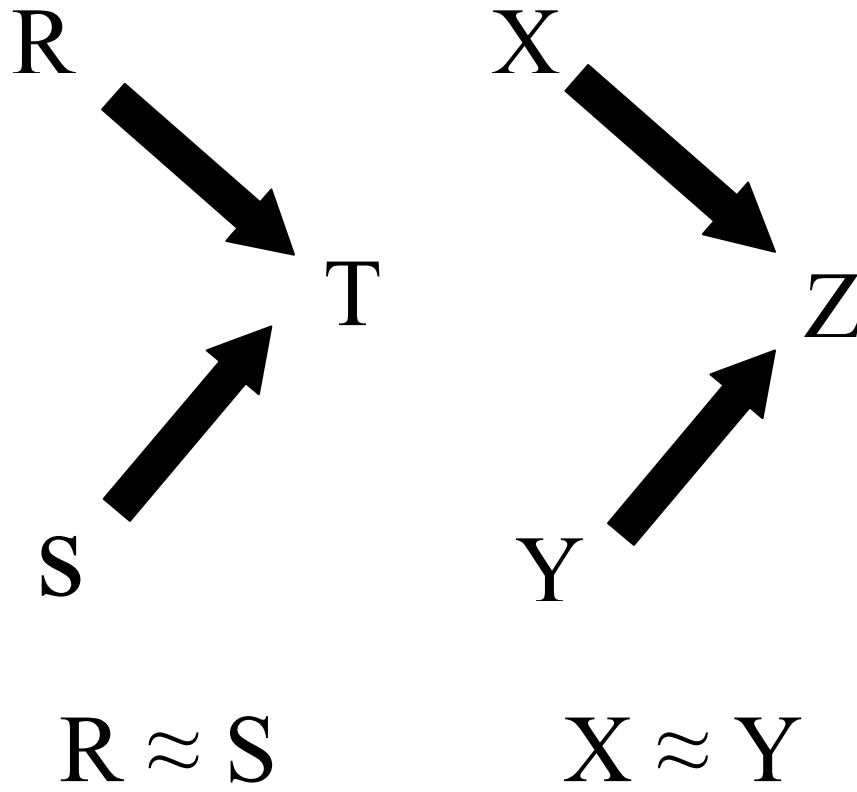
One such method is common coding of information. Common coding is known to be the process where two stimuli are associated with a common event on an individual basis. The two stimuli that had never been presented together form an association to each other through the common stimulus and therefore have something in common with each other (e.g., Urcuioli, Zentall, Jackson-Smith & Steirn, 1989). An illustration of common coding may be seen in Figure 1.2. It is believed that the animals “code” two stimuli as belonging together if they either produce the same outcome or have an association with a common stimulus.

Reese (1972) was interested in a related phenomenon (acquired equivalence) and acquired distinctiveness in children. Reese tested equivalence in children around the same age that Piaget believed a person had to be to perform the transitive inference tasks (i.e., kindergarten, first and second grade).

Acquired equivalence was seen when a subject would, over time see two different stimuli as leading to the same responses, although the stimuli were not presented together. Acquired distinctiveness is more of a contrasting effect. Through associations it is learned that the two stimuli are not related or common and are therefore very distinct in the context in which they are presented. Trapold (1970) found that different food outcomes produces acquired distinctiveness in animals. This is known as the differential

Figure 1.2

Common Coding occurring through the association of two different stimuli to the same outcome.



outcome effect. Urcuioli (1990) continued the study of acquired distinctiveness and equivalence. He was interested in exploring the idea that conditional discriminations enhance performance through the use of differential outcomes.

Urcuioli (1990) suggested the outcome that is provided in association with an individual stimulus could have an effect on task performance. This is known as the differential outcome effect. When stimuli are associated with different outcomes, then it is possible for the subject to anticipate the outcome that is to come later in the trial. An example of how the differential outcome effect works is that if choice of stimulus A receives green food and choice of stimulus B receives red food then when the stimulus is presented in later trials the subject should be able to anticipate which food will be given.

There are other suggestions as to how this effect works. For example, the samples could possibly be more discriminable when they are associated with different outcomes as opposed to identical outcomes. This suggestion is in line with the idea of acquired distinctiveness that was investigated by Reese (1972).

Urcuioli (1990) found that differential outcomes produced faster training of associations when the outcome was the same for the original and substitute stimuli. In addition, he found that when using similar outcomes as compared to different outcomes the level of accuracy in a task was higher and pigeons demonstrated an increased ability to retain the information for longer periods of time. Urcuioli (1990) concluded that positive transfer performance showed that the subjects were able to form a map so that the different stimuli were equal based on the outcome. Urcuioli (1990) demonstrated that the pigeons viewed the stimuli as a common code.

Experiments such as the one by Urcuioli (1990) are the best examples of common

coding since they use a transfer of information. Further elaboration on the topic reveals that if memories for samples were constructed of similar representative codes then the rate of memory decay would be similar between the two coded stimuli (Zentall, Sherburne & Urcuioli 1993).

Zentall et al. (1993) suggested that if two stimuli share a common code, then one stimulus should be able to substitute for the other. They found support for their hypothesis. Grant and Spetch (1994) found that pigeons can commonly code visual and time duration stimuli. Even though there is empirical evidence for a common code, the method of how the code is formed remains to be found (Grant & Spetch, 1994).

Zentall, Sherburne and Urcuioli (1995) suggested that if training resulted in common coding then it should be possible to demonstrate the relationships in ways other than what has been discussed thus far. In an attempt to identify the form of the common code that is developed during an experiment, samples that have previously been able to produce distinct patterns of retention were used.

Zentall et al. (1995) used both hue samples and hedonic samples to test the hypothesis that through the distinct training of samples the nature of the code used should be evident in the relationship that was formed between the sample and comparison. They found that pigeons could learn to code the hue samples and the hedonic events when both were associated with the correct responding to the same comparison.

Reese (1972) stated that it is more difficult to discriminate between stimuli that have been associated with the same comparison than it is for those that had different comparisons. Kaiser, Sherburne, Steirn and Zentall (1997) also thought that if samples are commonly coded then it should be harder to discriminate between those samples than

samples not commonly coded. They tested between pigeons that had been trained to stimuli that received the same outcome and a group that received distinct outcomes. A decreased ability to make that discrimination between stimuli that share a common comparison was found.

If stimuli that are paired with a common outcome are commonly coded, and therefore less discriminable than stimuli paired with different outcomes (not commonly coded) then, commonly coded stimuli along a TI array ($A > B > C > D > E$) may interfere with the Transitive Inference process. The present study was an attempt to determine if commonly coded stimuli would have an effect on performance on a transitive inference task. Transitive inference and common coding are both cognitive processes that function to help animals place information into memory.

The question of the present study was if pigeons are trained on a transitive inference task and the stimuli along the linear array are grouped by a common code, then would that grouping have any influence, either through enhancement or interference, on the transitive inference performance. For example, in a transitive inference ($A > B > C > D > E$) stimulus B will be chosen over D at a level higher than chance. However, if stimulus D and A received the same outcome (and thus are grouped together) would it be harder for the pigeon to make a choice between stimulus B and D? Transitive inference would predict a preference for B, but the common code between A and D could contribute a value to the lesser stimulus in the transitive line to a degree that D would have as much value as B. This question was tested by having the pigeons train in a transitive inference task while at the same time receiving similar outcomes for some of the stimuli along the stimulus array.

There are several hypotheses proposed here that accompanied the transitive inference task and test. First of all, if stimulus A and B receive a common outcome then the pigeons should show a stronger preference in the test for B (over D) than in a control group without common coding. This is because the pigeon would learn through both transitive inference and common coding that B is stronger than D.

Secondly, it was predicted that when stimuli A and D received a common code then test performance would fall closer to chance than a control group. This group should help demonstrate the relative strengths of the two processes: common coding and TI.

The third hypothesis was that when stimuli B and D receive the same outcome they would be less discernable from each other than in the control group. It was predicted that in this group the pigeons would test at or near chance which would support previous research that has demonstrated it is harder to make a choice between two stimuli when they have been receiving a similar outcome (Kaiser et al., 1997; Neiman & Zentall, 2001). Common outcomes were provided by illuminating a food reward with a colored light.

Chapter 2

Method

Subjects

There were 20 adult White Carneaux pigeons of mixed sex used in this experiment. The pigeons were acquired from the Palmetto Pigeon Plant where they were used for breeding purposes. All of the pigeons were experimentally naïve. The pigeons were housed individually in a colony room with a 12-hour light/dark cycle. They were maintained at 80% of their free feeding body weight and fed with mixed grain both in the operant chamber and in the colony room. However, they did have free access to water and grit while in the colony room.

Apparatus

A modified operant chamber was used to conduct this experiment. The inside of the chamber measured 35 cm high x 30.5 cm wide x 35 cm across. On the front wall was a food magazine that was illuminated when the reward was presented. The bottom edge of the magazine opening was 7 cm from the floor of the chamber. The magazine chamber was capable of casting a red light or green light over the food to give the food different appearances without changing other properties of the reward.

Above the magazine were three keylights lined in a horizontal row so that there was a left key, center key and right key. In this experiment only the center and right key were used. The three round keys were each 3 cm in diameter and were mounted 3.5 cm apart from edge to edge. The bottom of each key was 19 cm from the floor of the chamber. The keylights were pressure sensitive. Each keylight had a projector behind it that was capable of presenting colors on the keys (red = R, yellow = Y, white = W, blue =

B, green = G). There was a house light located at the midline of the response panel 6 cm above the pecking key to provide illumination to the chamber.

The other three walls were blank except for the door to the chamber. The door had a window so the experimenter could observe the pigeon in the chamber; however, from the inside this would function as a one-way mirror so the pigeon was not able to see outside of the chamber. The chamber itself was housed in a separate room in the laboratory so that there would not be any lights or visual distractions for the pigeon while inside the chamber.

A speaker was attached to the same panel as the keylights so that there was a constant white noise present. The purpose of this was to mask any distracting noise from outside the chamber. Additional masking noise was provided by a ventilation fan used to circulate air in the chamber. The operant chamber was connected to a computer in an adjacent room that was used to control the stimulus presentation and data recording.

Procedure

Each bird went through identical training phases before beginning the experiment. Each bird was magazine trained to learn when food was available in the lighted magazine chamber. The food presented was illuminated with a light that was randomly either red or green. Magazine training continued until the pigeon was able to respond as soon as the illuminated food was presented.

After the magazine training was complete the pigeons went through shaping, in which the birds were trained to peck illuminated keys for food. In shaping sessions each color (red, yellow, white, blue, and green) was presented twice on each key (center and right) for a total of 20 trials. The color of key illumination in the shaping session varied

on a random basis with the restriction that neither the same color nor the same location appeared more than three times in a row. Once a pigeon completed one session of 20 trials with a fixed ratio (FR) of one it then had to complete two similar sessions with a FR5. Once a bird completed the shaping phase it was randomly assigned to one of four groups and began TI training.

A trial consisted of two different colored stimuli presented simultaneously on the center and right keys. The pigeon responded on a FR5 to one of the presented stimuli.

In the training sessions the pigeon received a 2.5 second reinforcer if the correct key was pecked. The choice also resulted in the onset of a 10-s intertrial interval (ITI), followed by the next trial. If the correct key was chosen then the reinforcer was presented during the first 2.5 seconds of the ITI. The houselight remained on throughout the session.

A session consisted of 96 trials and was conducted once per day for each pigeon. Each bird performed six days a week within an hour of the assigned session time. The stimuli remained the same throughout the session. However, the place of presentation was random with the restriction that a single color was not presented more than three consecutive times on the same side. The positive stimuli remained the same for the length of the session.

The sessions were the same for two days and then the order of presentation across trials was reversed the following two days. This order continued until the pigeon obtained a criterion of 90% correct on two consecutive sessions. The bird also had to spend at least three days on each phase. There were four training phases (A+B-, B+C-, C+D-, D+E-).

After the four training phases were complete each pigeon received the test session. The test followed the completion of Phase Four even if it occurred on the seventh day of the bird's week. The test was one session of 24 trials. Each test trial consisted of the presentation of stimuli B and D from the training phases. Reinforcement occurred on a random schedule of the stimulus choice for 24 trials. Choice of the stimuli was rewarded with food that was illuminated with the same color as the training phase for that stimulus.

Each bird was randomly assigned to one of four groups: Control Group, Within Common Coding Group, Between Common Coding Group One, and Between Common Coding Group Two. The conditions were counterbalanced across all groups. (See Table 2.1).

In the Control Group the pigeons randomly received red food for half of the correct trials in a session and green food for the other half. This should have allowed a replication of the traditional findings for transitive inference and it provided a comparison to the other groups in this experiment.

For the Within Common Coding Group, in training, correct choices of stimuli A and C were followed by red food, while correct choices of B and D were followed by green food. In the test the birds in this group had a choice between stimuli B and D, which had been followed by similar outcomes during the training phases.

For the Between Common Coding Group One correct choice of stimuli A and B were followed by outcomes of red food and C and D with green food. For the Between Common Coding Group Two, correct choices of stimuli A and D were followed by red food outcomes, with correct choices of B and C followed by green food.

Table 2.1

Group Conditions and Counterbalanced Groups for Common Coding and Transitive Inference

Phase	I	II	III	IV
Non-Differential Control				
A B C D E	$A^{R/G}B-$	$B^{R/G}C-$	$C^{R/G}D-$	$D^{R/G}E-$
	$A^{G/R}B-$	$B^{G/R}C-$	$C^{G/R}D-$	$D^{G/R}E-$
Within Common Coding				
I-----I				
A B C D E	A^RB-	B^GC-	C^RD-	D^GE-
I-----I	A^GB-	B^RC-	C^GD-	D^RE-
Between Common Coding One				
I--I				
A B C D E	A^RB-	B^RC-	C^GD-	D^GE-
I---I	A^GB-	B^GC-	C^RD-	D^RE-
Between Common Coding Two				
I-----I				
A B C D E	A^RB-	B^GC-	C^GD-	D^RE-
I---I	A^GB-	B^RC-	C^RD-	D^GE-

A counterbalanced group was run with every condition. To counterbalance the condition the color of the reinforcement light was reversed (e.g., if A and C receive a red outcome then in the counterbalanced group, A and C receive green food). This method of counterbalancing was used in every condition and across all stimuli.

Chapter 3

Results

On average, the birds completed the four training phases and the test in 14.90 sessions. The minimum number of sessions in which each bird could finish was 13 sessions, three for each of the four phases and one for the test session. There was not a difference in sessions to complete training among the counterbalanced groups.

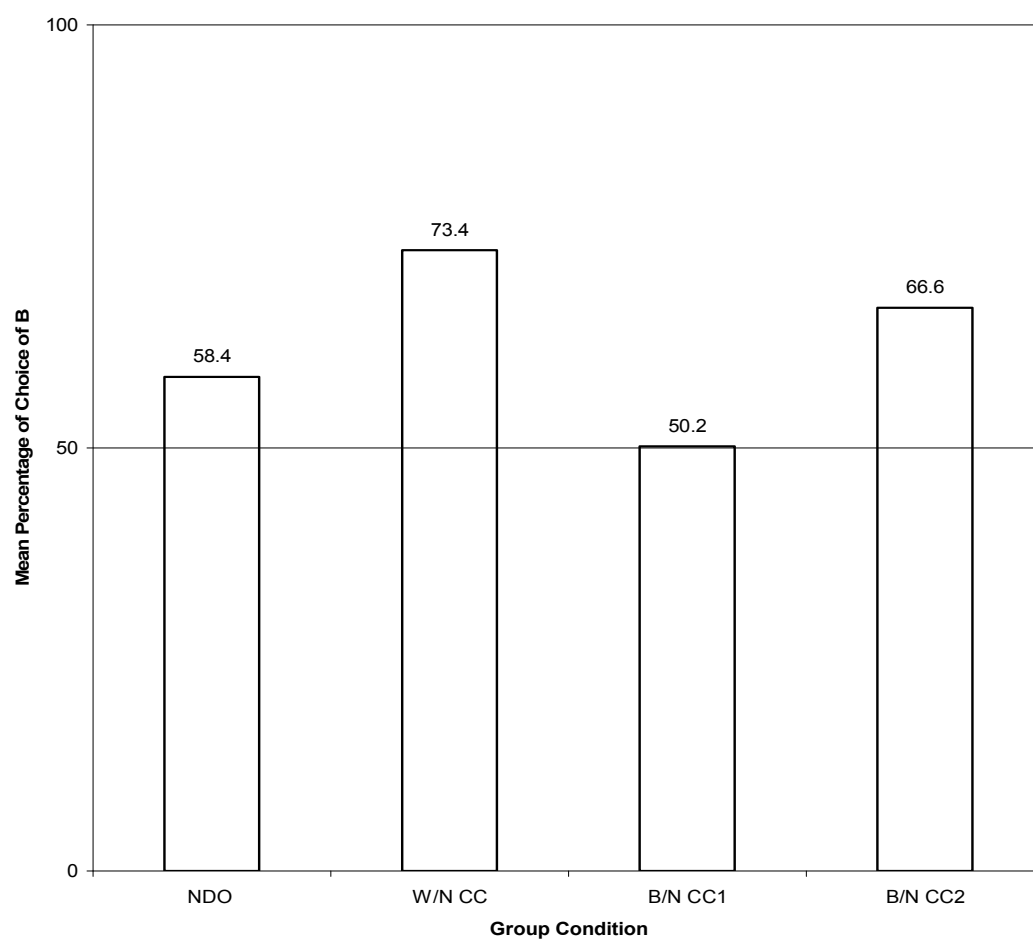
Test performance was analyzed by comparing the rate of responding to Stimulus B to chance (50%). A single sample, one-tail t -test was used to determine whether or not Transitive Inference occurred across the conditions. Overall, choice of stimulus B ($M = 62.15$, $S.D. = 18.52$) was significantly higher than chance, indicating TI performance was present across all of the birds, $t(19) = 2.93$, $p < .05$.

The individual conditions did not show significant choice of stimulus B or D in the test. The means for the different conditions can be seen in Figure 3.1. The Non-differential Outcome Control Group choice of B was not significantly different from chance, $t(4) = 1.14$, $p > .05$. In the Within Common Coding group the choice of B was also not significantly higher than chance, $t(4) = 2.41$, $p > .05$. The Between Common Coding Group One did not perform at a level different where choice of B was different from chance, $t(4) = .03$, $p > .05$. In the Between Common Coding Group Two rates of responding for choice B was similar to chance, $t(4) = 2.13$, $p > .05$.

In addition, a One-way Analysis of Variance was used to determine whether there was a difference in performance across the groups. There was not a significant difference among the different groups in their choice of B over D, $F(3,16) = 1.62$, $p > .05$.

Figure 3.1

Mean rates of responding to stimulus B in the Transitive Inference task across the different experimental groups.



Chapter 4

Discussion

This experiment was performed in order to test whether grouping various stimuli with similar outcomes would have any effect on Transitive Inference performance. There were three main hypotheses in this experiment. The first was that if the strongest and second strongest stimuli (A and B) in the linear array received the same outcomes then in the test stimulus B would be preferred over stimulus D more so than in the Control group. The second hypothesis suggested that if strongest stimulus on the linear array and the weaker test stimulus were paired then there would be a weaker preference for stimulus B than in the Control group. The third hypothesis of this study was that if the two stimuli used in the test received similar outcomes, then in the test there once again should not be a preference for either of the stimuli.

The findings of this experiment indicate that Transitive Inference did occur on an overall level across all of the birds. Although it was hypothesized that in the Within Common Coding and Between Common Coding Two groups would not have a significant difference in the choice of B over D.

In addition, the Between Common Coding Group One should have also resulted in a strong preference for stimulus B because it was the stronger of the test stimuli along the linear array as well as being paired with the strongest of all of the stimuli in the array (A). Therefore, if the manipulations had been effective in this experiment than Between Common Coding Group One should have performed at a higher level on the test than the Control Group.

However, the failure to find the hypothesized differences suggests that the manipulations used did not result in common coding. Therefore, it is impossible to determine what effects might be found in the presence of common coding. It is possible that the manipulations did not have an effect in the experiment because the criterion to advance to the next phase was only three days of training to each stimulus pair if the bird was accurate in those sessions. Since the birds averaged finishing all of the phases and the test in 14.90 sessions this may not have given them enough time to form an association between the correct stimulus in each phase and the color of food that was given if the correct choice was made.

Even if the birds had not made the connection between the color of food that followed a correct choice and the stimulus itself then TI should have still been demonstrated in these groups. One possibility is that the small sample size of the groups did not allow enough statistical power to see differences from chance performance. Another possibility is that the pigeons paid enough attention to the color of the reinforcer for it to disrupt their normal behavior, even when the color of reinforcement should have theoretically enhanced the TI performance.

Future research in this area should address the same question as this experiment, except with a different method of training the birds. For instance, the next step to take should be to train the pigeons to the same stimuli and outcomes as this experiment but to also provide more instances of seeing the stimulus-outcome pairing. This could be accomplished by using autoshaping to train the pigeons to peck at the lights instead of manual shaping as was used in the current experiment. This would provide a single stimulus on a fixed time schedule and then the colored outcome would follow the

stimulus whether responding had occurred or not. This should present the bird with additional time to begin forming an association between the stimulus and reinforcement without influencing behavior in the TI training procedure.

In conclusion, the procedure in this study may not have allowed the association between the stimulus and color of reinforcement to be formed. If the association was not formed then the stimuli along the linear array may not have been commonly coded as was intended through the procedures that were used. Further research with additional procedures is necessary to draw solid conclusions as to whether or not stimuli that are coded to be the same would have an effect on Transitive Inference performance.

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